A Hybrid Artificial-Intelligence Predictive Model for Crude Oil Demand: A Case Study for a High Producer and a High Consumer

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Abstract

This paper develops a rigorous and advanced computational model to describe, analyze, and forecast global crude oil demand. The paper deploys a hybrid approach of artificial intelligence techniques: artificial neural network and genetic algorithms, to devise a methodological framework for developing forecasting models of global crude oil demand. We piloted two country cases of a high oil producer (Saudi Arabia) and a high oil consumer (China) to illustrate the effectiveness and applicability of the proposed methodology for developing oil demand outlook using artificial intelligence.

The input variables of the neural network models include gross domestic product, population, oil prices, gas prices, and transport data, in addition to transformed variables and functional links. The artificial intelligent predictive models of oil demand were successfully developed, trained, validated and tested using historical oil-market data yielding excellent predictions of oil demand. The performance of the intelligent models of Saudi Arabia and China were examined for generalization attribute, predictability, and accuracy. Oil demand models for Saudi Arabia and China achieved a high prediction accuracy of a correlation coefficient of 0.975 and 0.996, respectively.

The intelligent outlook models show that crude oil demand for both Saudi Arabia and China will continue to increase for the outlook period (2018-2022) but with mildly declining growth. This falling growth of oil demand can be attributed to the increase in energy efficiency, fuel switching, conversion of power plants from crude to gas-based plants, and an increase in the utilization of renewable energy such as solar and wind for electric

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generation and water desalination.

The methodology proposed improves and enhances the conventional process of developing the oil demand outlook. It also improves and enhances the predictability and accuracy of current forecasting models of oil demand. In this study, features selection techniques are applied to identify and understand the endogenous and exogenous factors that influence global energy markets, particularly those factors that impact and drive global oil demand.

Keywords: Oil demand, Artificial intelligence, Demand forecasting, Saudi Arabia, China

Overview

The development of domestic and global oil demand outlooks is a crucial task for energy planning, formulating strategies and recommending energy policies. Undertaking this mission is an important and challenging endeavor as it can impact the economic trajectory of countries or the bottom line of energy companies and related industrial sectors. The purpose of this paper is to develop a rigorous computational model to describe, analyze, and forecast crude oil demand using an artificial intelligence approach for a high oil producer (Saudi Arabia) and a high oil consumer (China).

Intelligent models of oil demand were developed with data from 1970 to 2016. The input variables of the neural network models include gross domestic product (GDP), population, oil prices, gas prices, and transport data, in addition to transformed variables and functional links. The artificial intelligent predictive models of oil demand were successfully developed, trained, validated and tested using historical oil-market data yielding excellent predictions of oil demand. The results of the intelligent oil demand models were also compared with published industry forecasts. The neural network models of Saudi Arabia (a high oil producer) and China (a high oil consumer) were successfully developed. The performance of the intelligent models of Saudi Arabia and China were examined for generalization, predictability, and accuracy. Oil demand models for Saudi

Arabia and China achieved a high prediction accuracy of a correlation coefficient of 0.975 and 0.996, respectively, indicating that the intelligent models captured very well the dynamics of oil demand for both countries.

Methodology

This paper implemented a hybrid approach of artificial intelligence techniques: artificial neural network and genetic algorithms, to develop a methodological framework for developing forecasting models of global crude oil demand. This paper piloted two country cases of a high oil producer (Saudi Arabia) and a high oil consumer (China) to illustrate the effectiveness and applicability of the proposed methodology for developing oil demand outlook using artificial intelligence. The intelligent models of oil demand were developed with data from 1970 to 2016. The input variables of the neural network models are selected using the features selection techniques of genetic algorithm and stepwise selection. These input variables include gross domestic product (GDP), population, oil prices, gas prices, and transport data, in addition to transformed variables and functional links.

Results

The neural network predictive models of oil demand were successfully developed, trained, validated and tested using historical oil-market data yielding excellent predictions of oil demand. The results of the intelligent oil demand models were also compared with published industry forecasts. The neural network models of Saudi Arabia (a high oil producer) and China (a high oil consumer) were successfully developed. The performance of the intelligent models of Saudi Arabia and China were examined for generalization, predictability, and accuracy. Oil demand models for Saudi Arabia and China achieved a high prediction accuracy of a correlation coefficient of 0.975 and 0.996, respectively.

The artificial intelligent model of Saudi Arabia was constructed with the following network design and architecture: multilayer perceptron (MLP) architecture, backpropagation learning algorithm, three-layer network with 15 input nodes and one

output node. We used ensemble model for Saudi Arabia oil demand with a varying hidden-layer nodes between 8 and 11 nodes. A logistic function was used for the hidden activation and an exponential function for the output activation.

Figure 1- Saudi Arabia Oil Demand Outlook Model

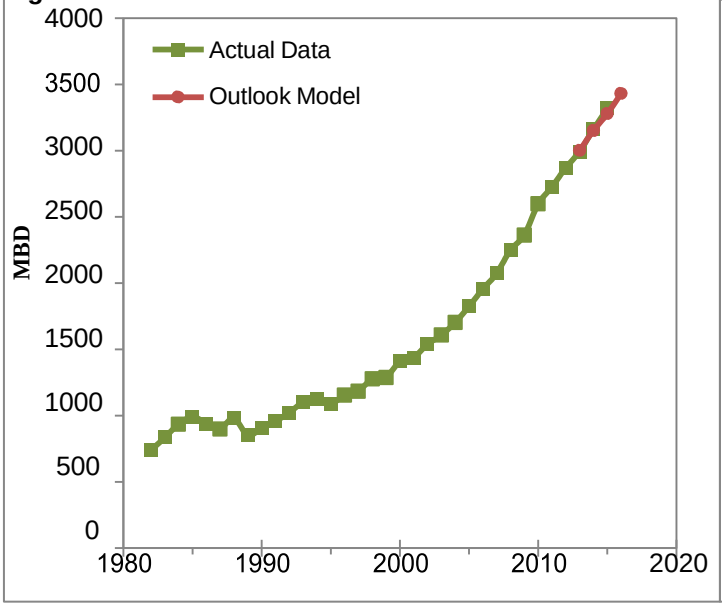

Figure 2- China Oil Demand Outlook Model

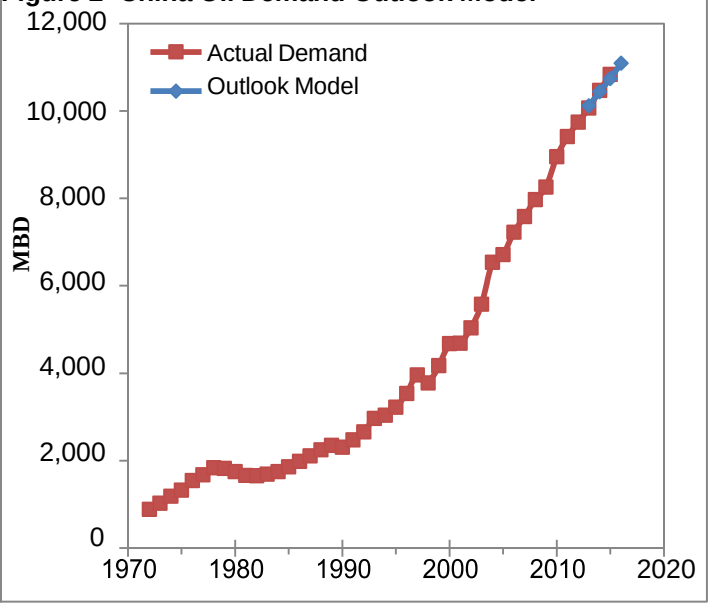

Fig. 1 & Fig. 2- Predictions performance validation of the hybrid AI predictive model compared to actual demand of Saudi Arabia, and China, respectively. Source: Author

Similarly, the China oil demand model was designed and developed as an artificial neural network model having: MLP architecture, backpropagation algorithm, three-layer network with 18 input-layer nodes, 14 hidden-layer nodes, and one input-layer node. A tanh function was used for the hidden activation and an exponential function for the output activation. The error function of sum of squares was used for all developed models of Saudi Arabia and China. Figure 1 shows the results of the artificial intelligent outlook model compared to the actual oil demand of Saudi Arabia. The AI outlook model of Saudi Arabia predicts very well the oil demand from 2013 to 2016. Figure 2 depicts the forecast of China oil demand from the AI outlook model compared to the actual oil demand. Similar to Saudi Arabia's model performance, the China oil demand model shows excellent performance of predicting oil demand from 2013 to 2016. It worth noting that these predictions are independent and apart of the model development.

Conclusion

Crude oil demand predictive models were developed using advanced analytics of artificial intelligence. The intelligent outlook models for Saudi Arabia and China showed excellent performance in prediction of crude oil demand. The models show that crude oil demand for both Saudi Arabia and China will continue to increase for the outlook period but with slightly declining growth. This falling growth of oil demand can be attributed to the increase in energy efficiency, fuel switching, conversion of power plants from crude to gas-based plants, and an increase in the utilization of renewable energy such as solar and wind for electric generation and water desalination.

This paper provides an advanced, rigorous, and cutting-edge modeling approach to our knowledge base of forecasting methods of crude oil demand. The methodology proposed improves and enhances the conventional process of developing the oil demand outlook. It also improves and enhances the predictability and accuracy of current forecasting models of oil demand. In this study, genetic algorithms are also deployed to identify and understand the endogenous and exogenous factors that influence global energy markets, particularly those factors that impact and drive global oil demand. Moreover, we recommend further application and use of the outlook models of oil demand developed in this study to perform sector and regional analysis, scenario-based analysis, energy policy analysis, and sensitivity analysis of influential factors.

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